Multi-century scenario development and socioeconomic uncertainty

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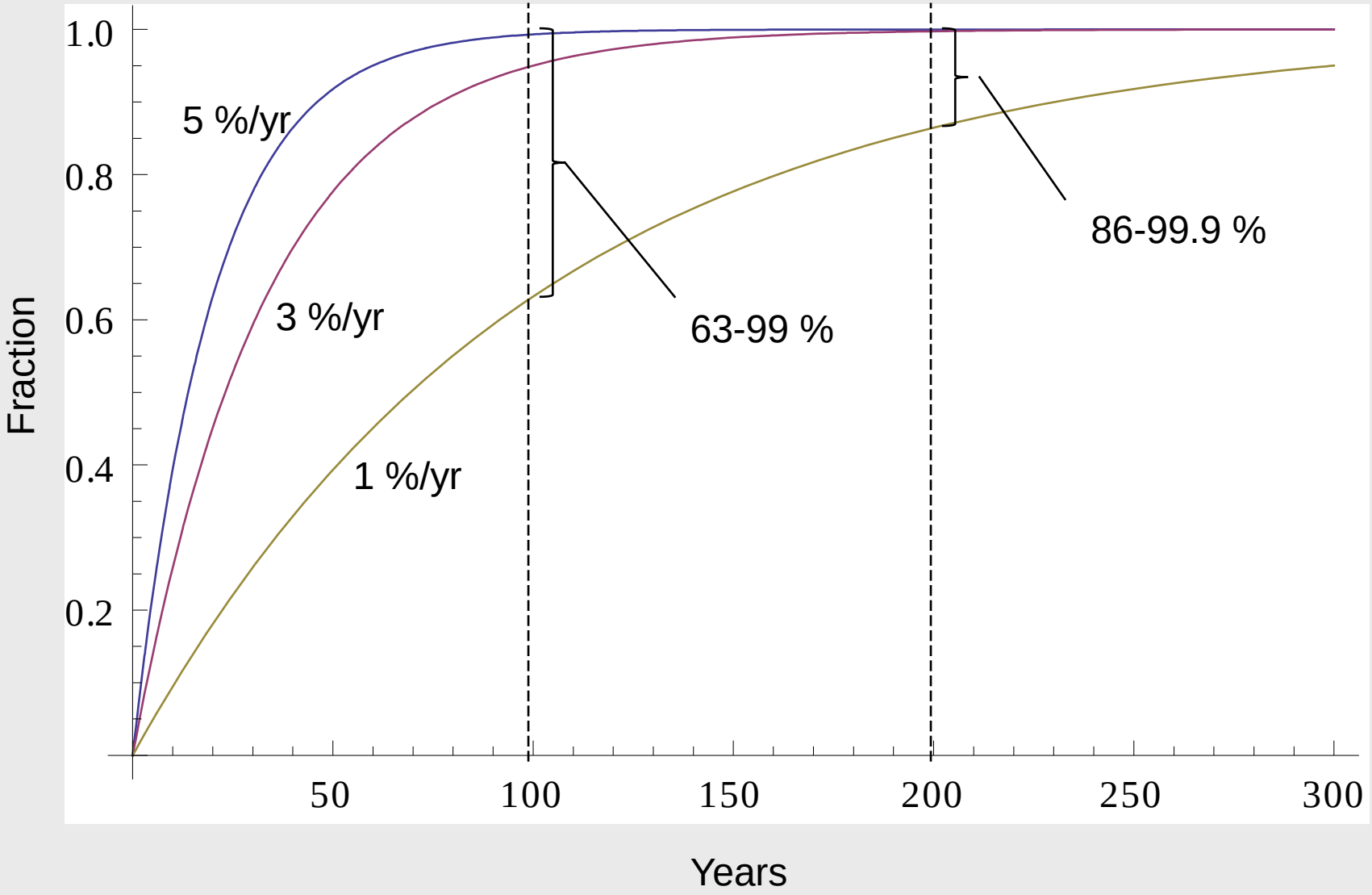
Does the long term matter?



Scenario variables and SCC approach

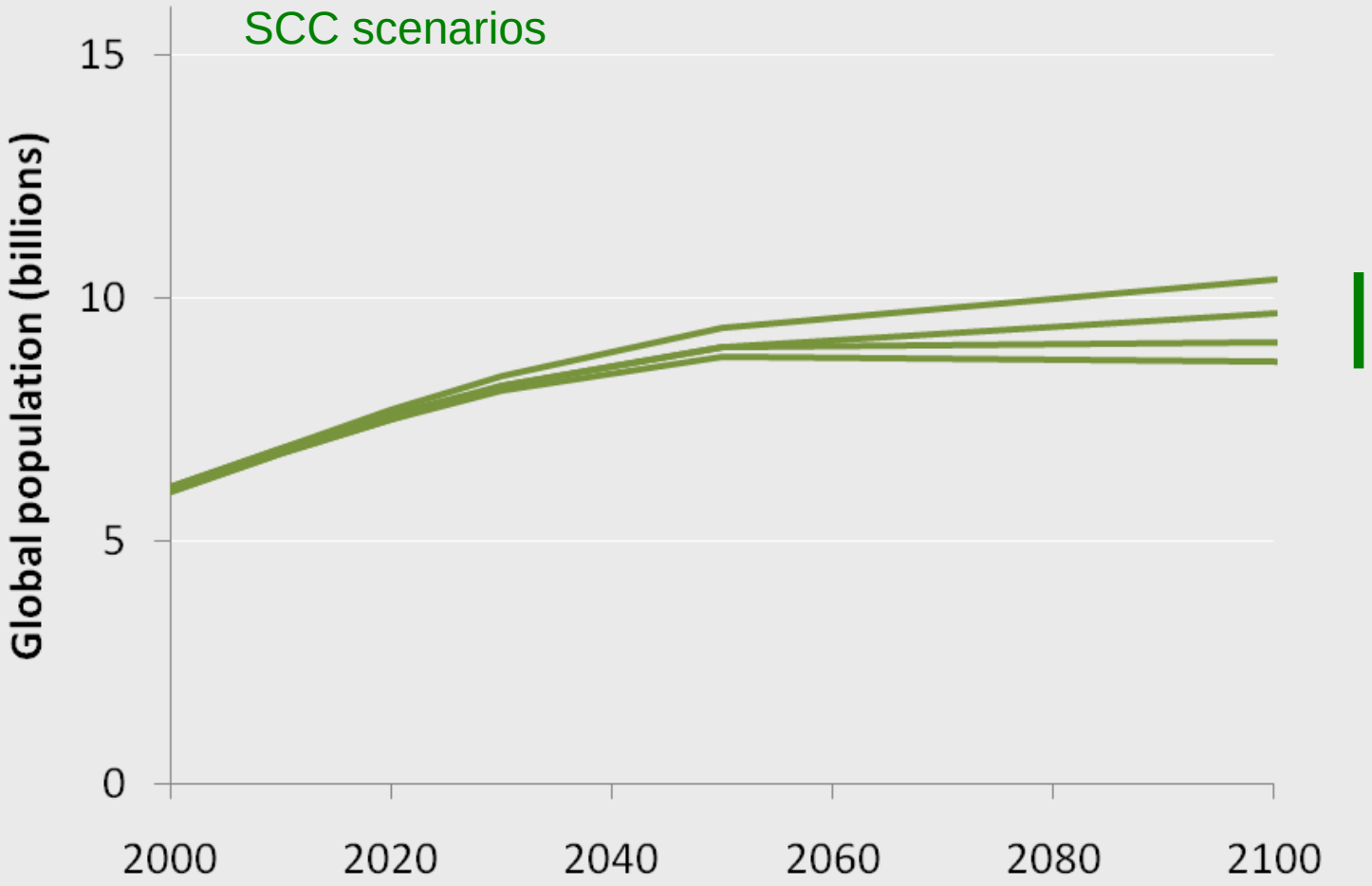
- **Population, GDP, CO2 emissions, non-CO2 forcing**
- **SCC approach**
  - "we aimed to select scenarios that span most of the plausible ranges of outcomes for these variables"
  - Select 5 scenarios from EMF-22 exercise, based on 4 models
  - "EMF BAU scenarios represent the modelers' judgment of the ***most likely pathway*** absent mitigation policies to reduce greenhouse gas emissions, rather than the wider range of possible outcomes. Nevertheless, ***these views of the most likely outcome span a wide range***…"
  - Extend from 2100 to 2300 for SCC calculation

Population and Uncertainty

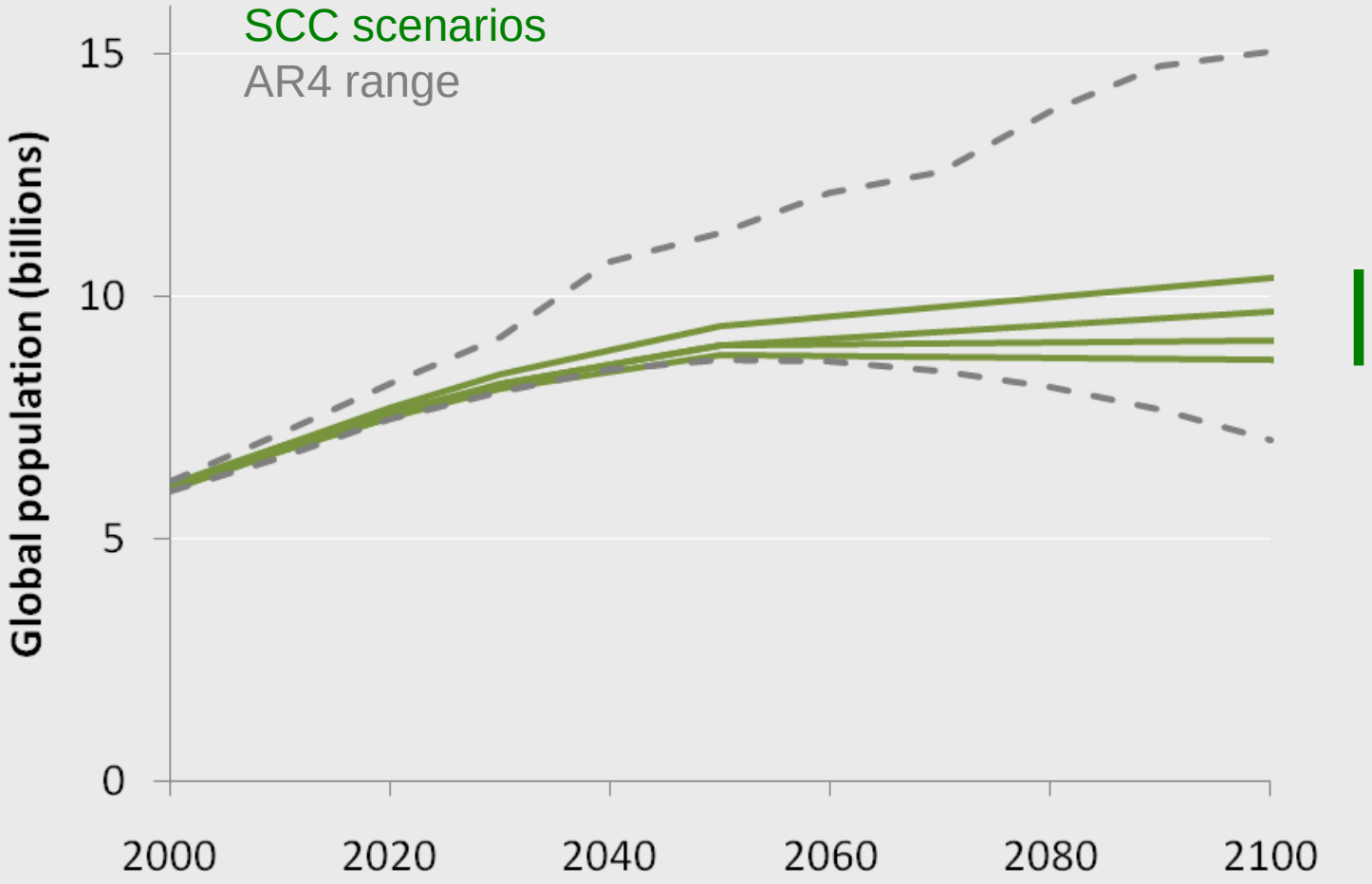
- **2010-2040**
  - **meaningful projections with well characterized uncertainty**
- **2040-2080**
  - **uncertainty begins to compound, but can still be usefully characterized**
- **Beyond 2080**
  - **compounding uncertainty, speculation about new conditions, limits, and feedbacks**

See UN, 2004; Lutz & Scherbov, 2008.

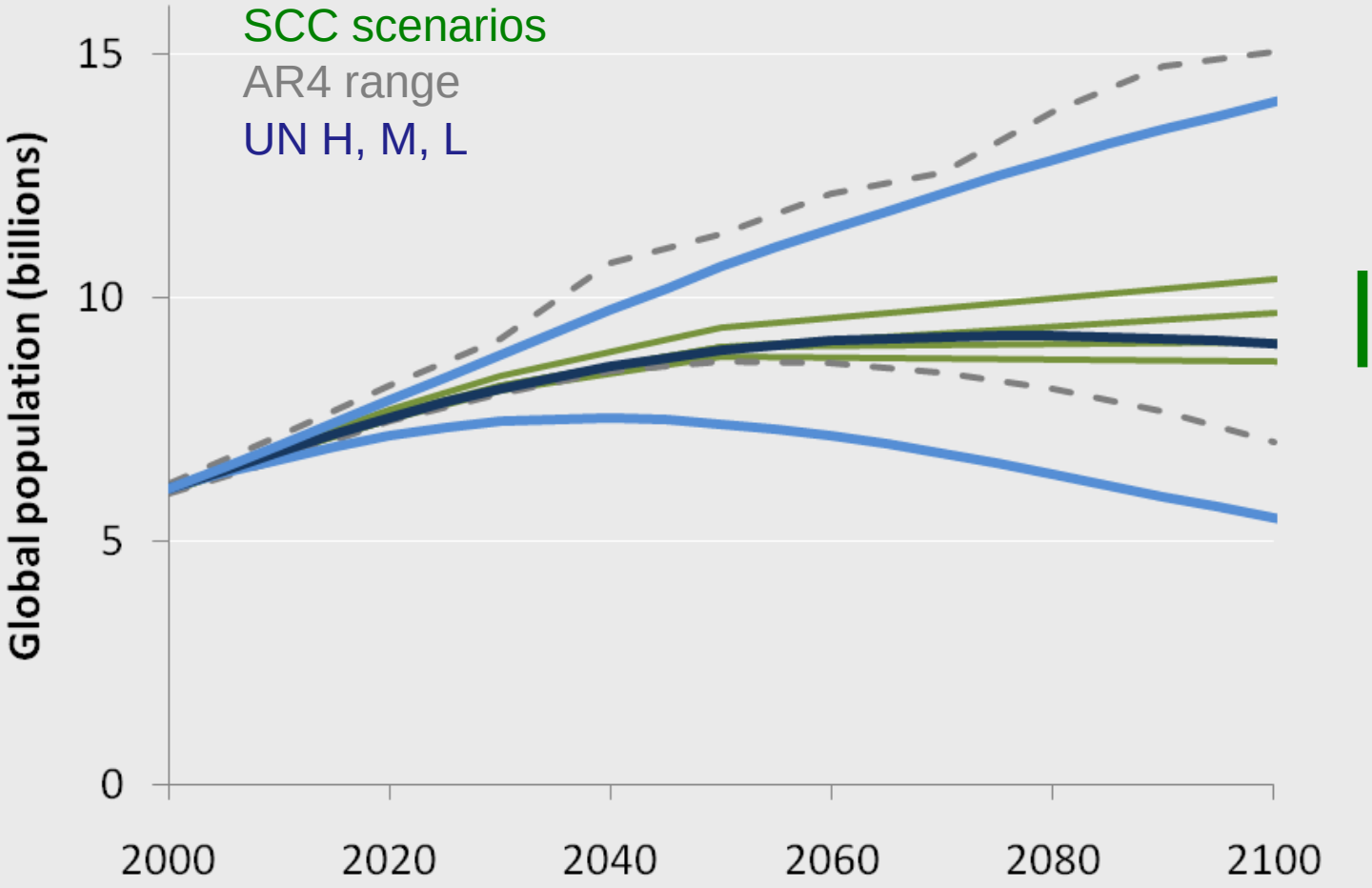
Global Population to 2100



Global Population to 2100

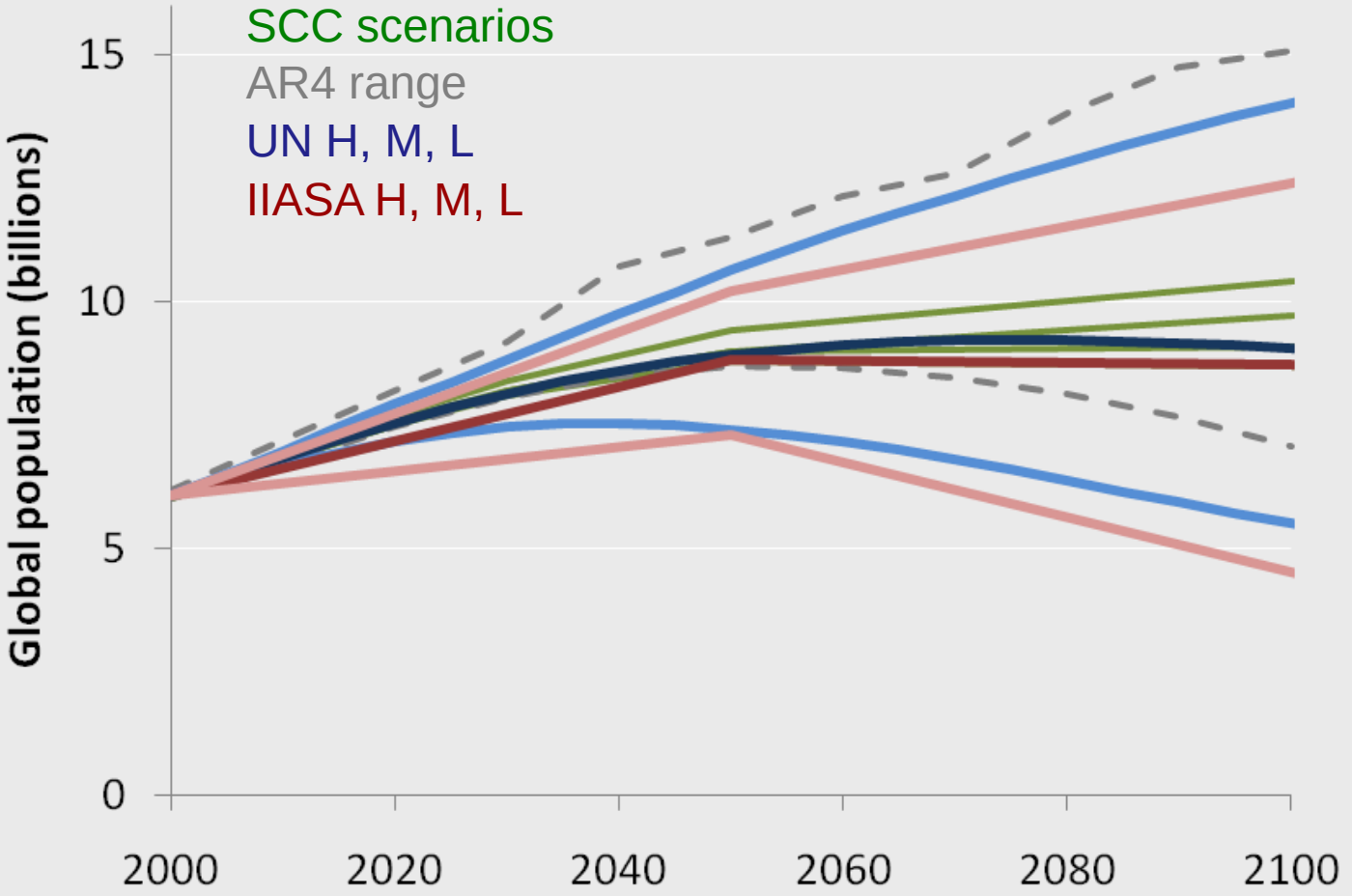


Global Population to 2100

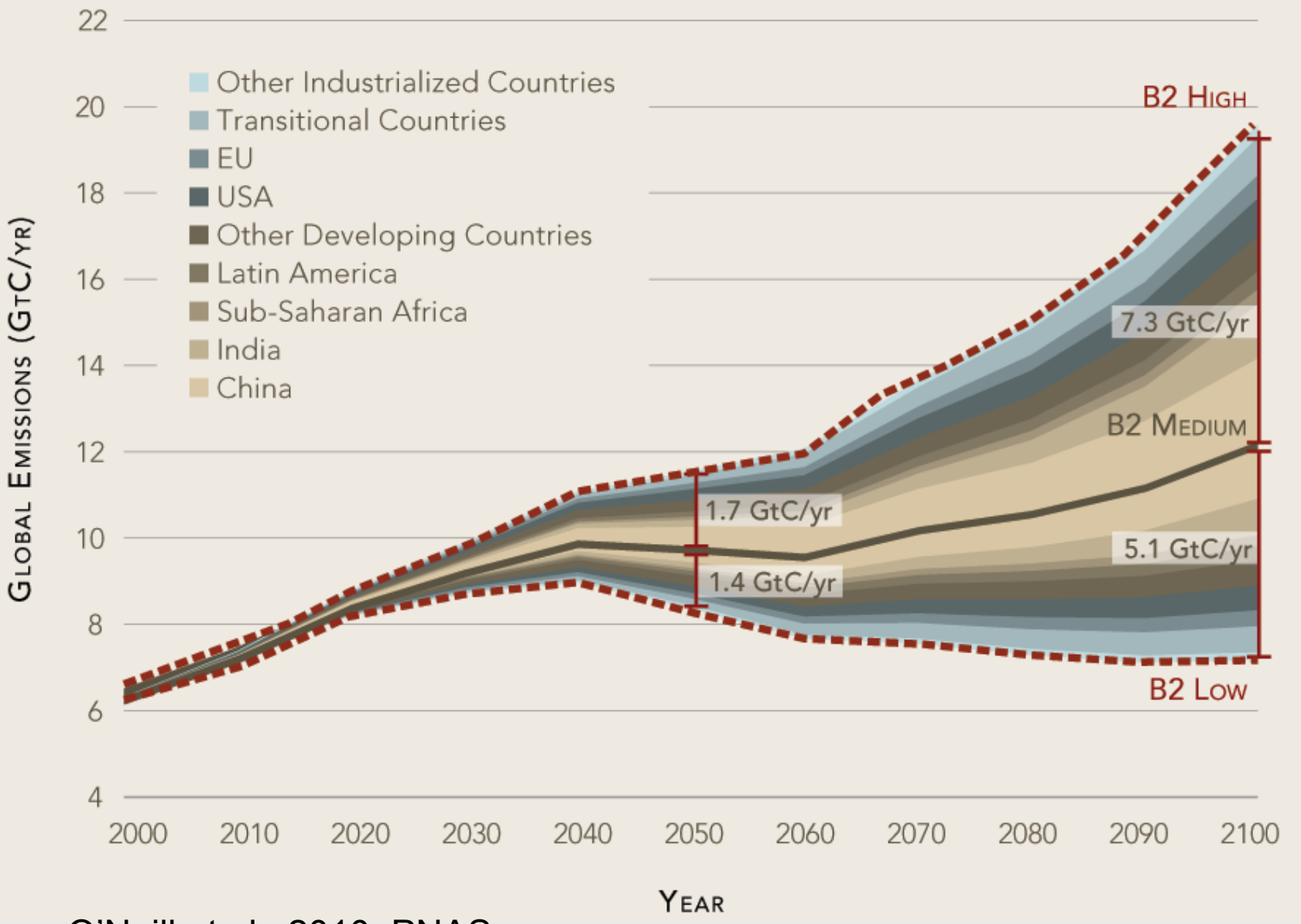


Global Population to 2100

H/L = 1.2 vs. 2.8



Effect of population on CO2 emissions

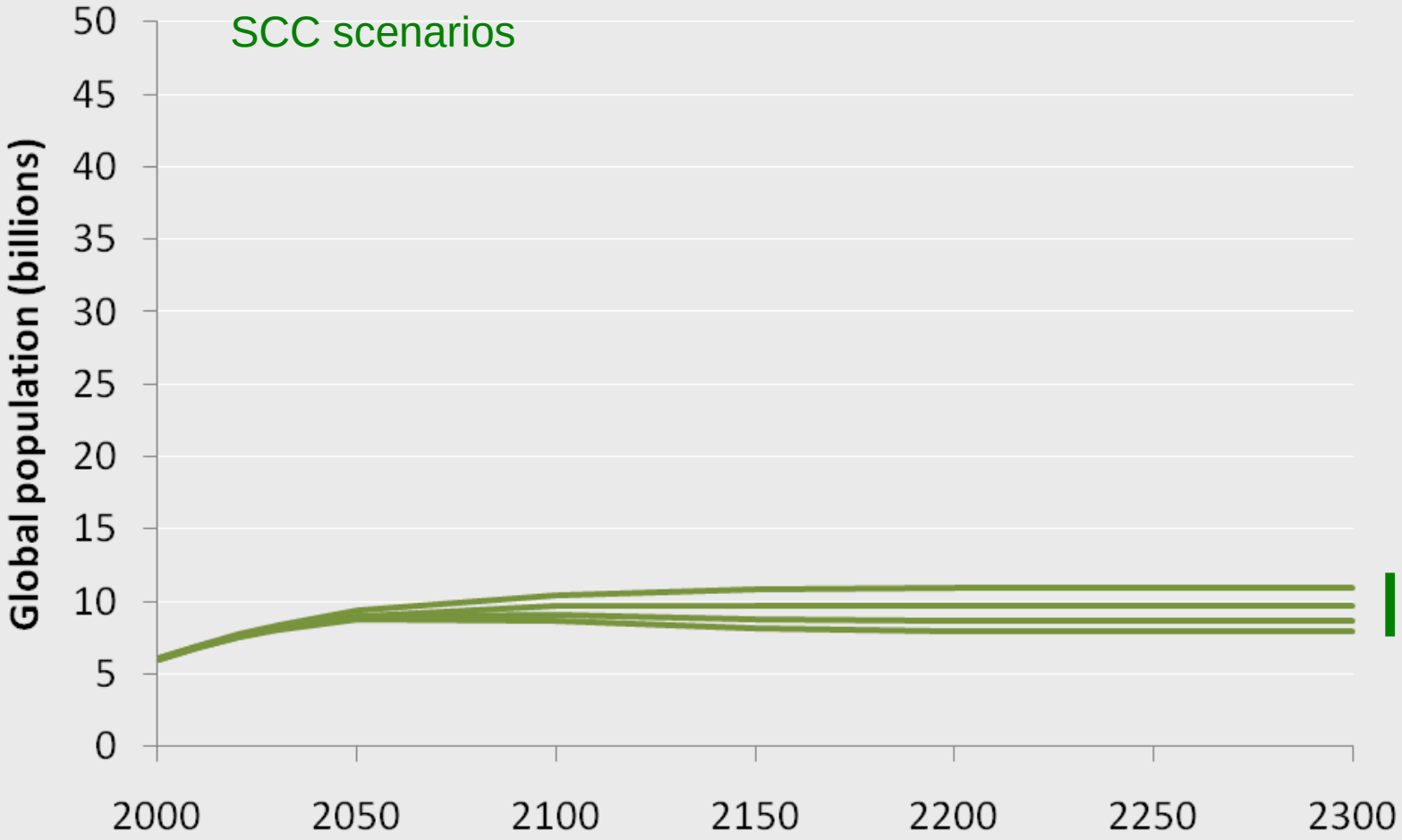


Source: O'Neill et al., 2010, PNAS.

SCC extrapolation to 2300

- Growth rates at end of 21st century decline linearly to zero by 2200
- “reasonably consistent with the United Nations long run population forecast, which estimates global population to be fairly stable after 2150 in the medium scenario”

Global Population to 2300

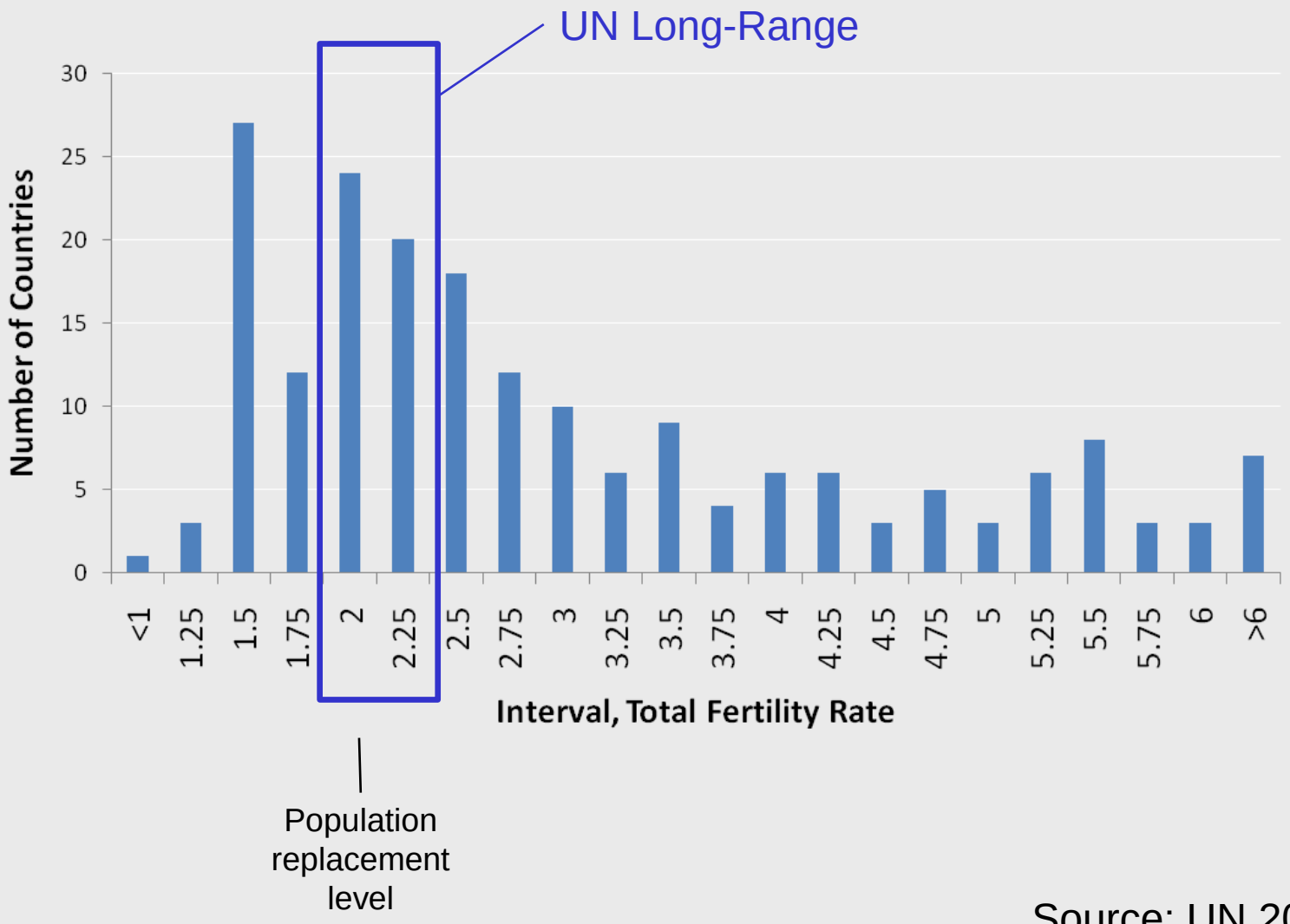


UN Long-Range Projections

- 2000-2300
- Country-specific
- Three fertility variants
  - Long-run convergence at 1.85, 2.05, 2.35
- Life expectancy increases throughout the period
  - from ~75 in 2050 to ~95 in 2300
- Migration zero after 2050

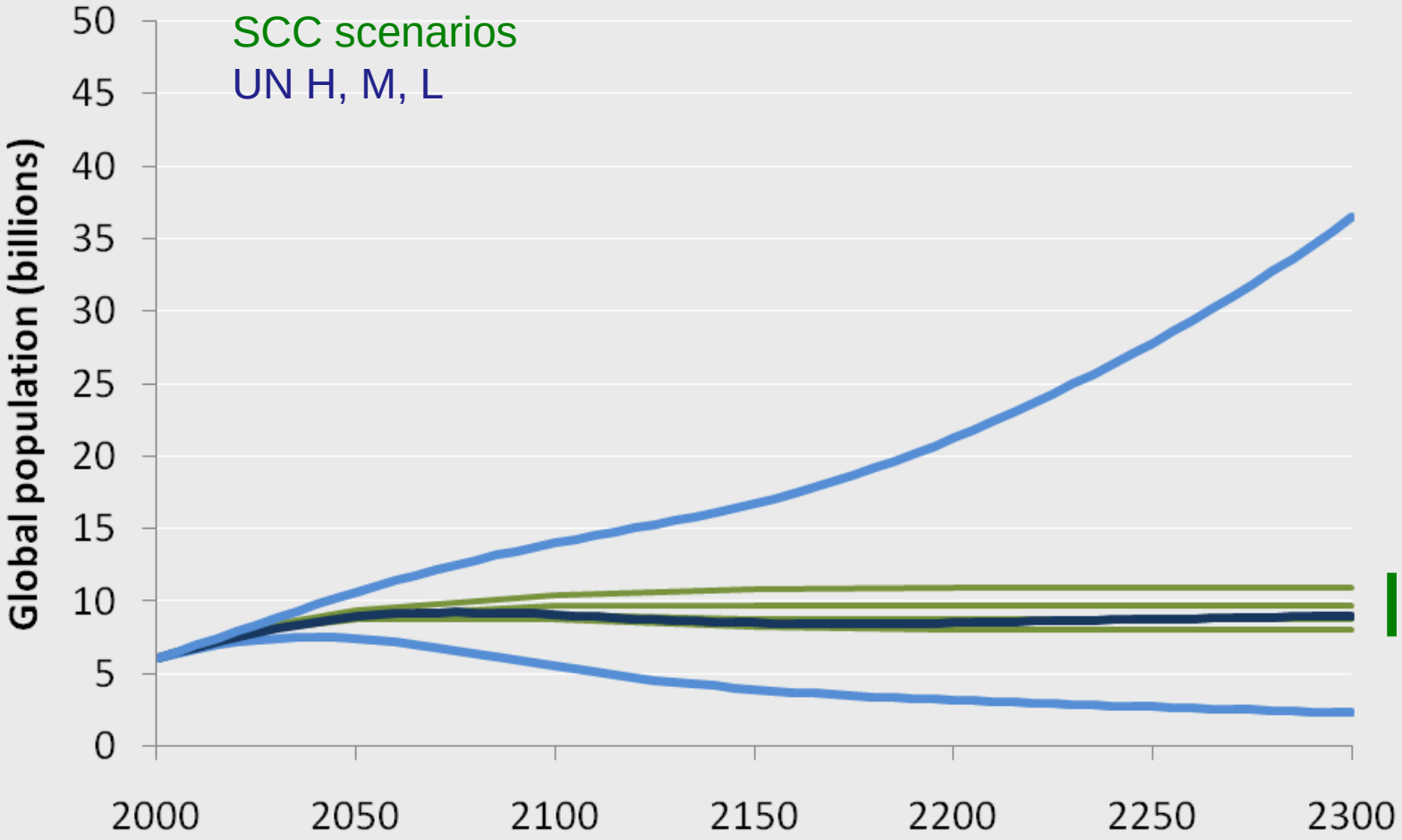
- Medium to 2300 is not the most likely! Designed to produce a roughly stable population size
- Value: illustrate the implications of small differences in future fertility levels

Distribution of national fertility rates, 2005-2010



Source: UN 2008.

Global Population to 2300

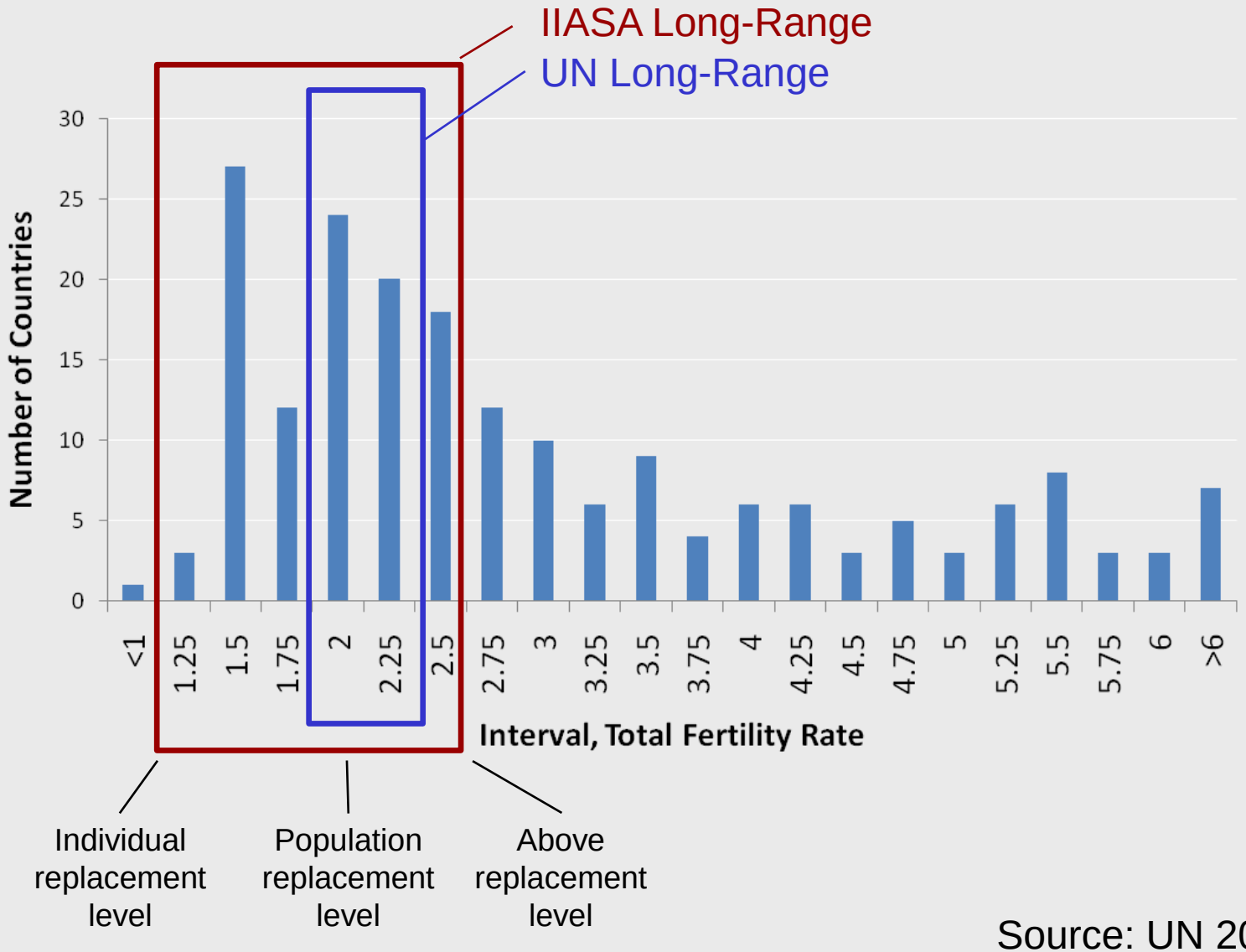


IIASA Long-Range Projections

- 2000-2300
- 13 world regions
- Four long-term fertility levels
  - Long-run convergence at 1.0, 1.5, 2.0, 2.5
- Life expectancy increases throughout the period
  - maximum life expectancy of 120
- Migration zero after 2080

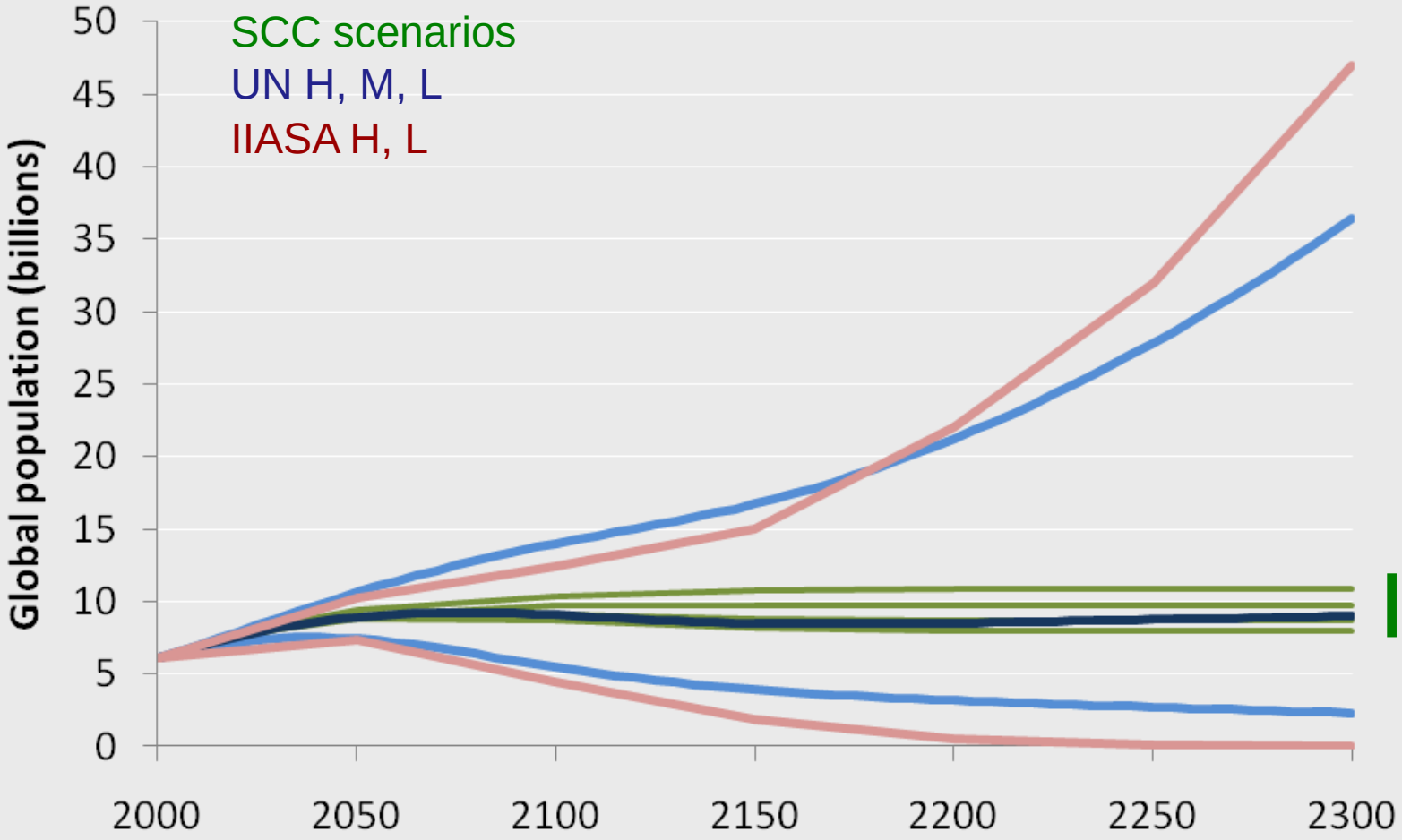
- Extensions to 2300 are not probabilistic
- Value: illustrate the implications of plausible range of future fertility levels

Distribution of national fertility rates, 2005-2010

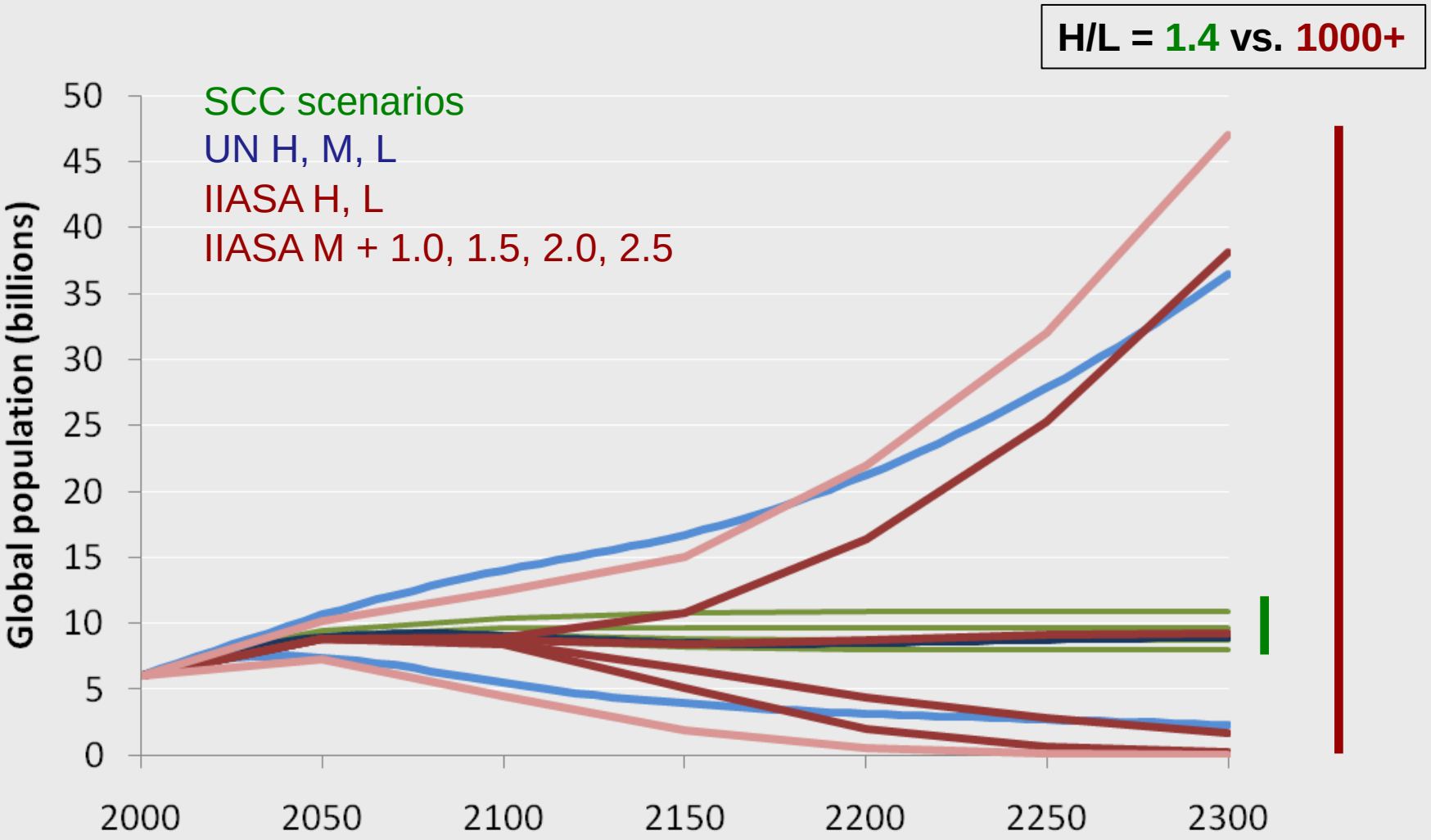


Source: UN 2008.

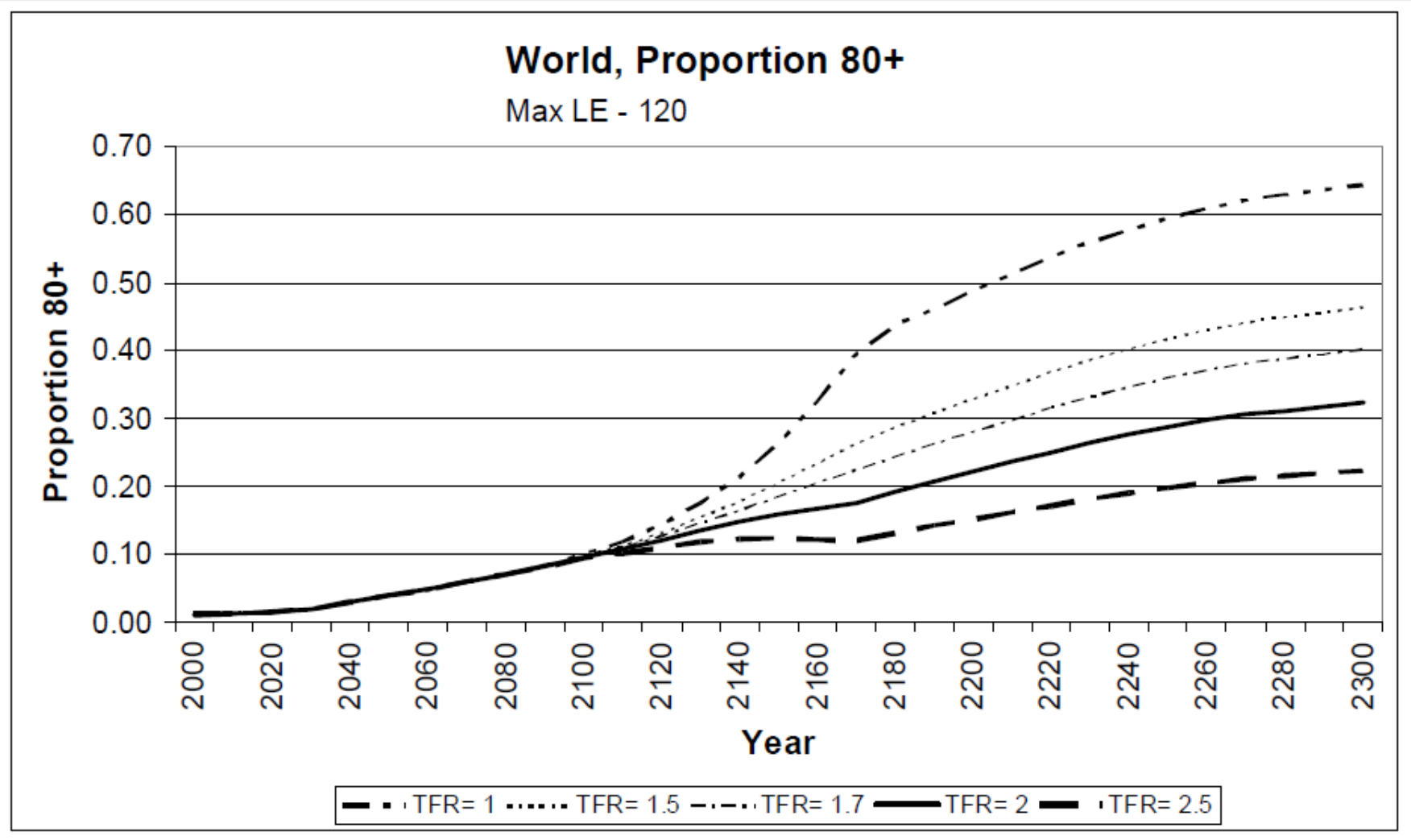
Global Population to 2300



Global Population to 2300

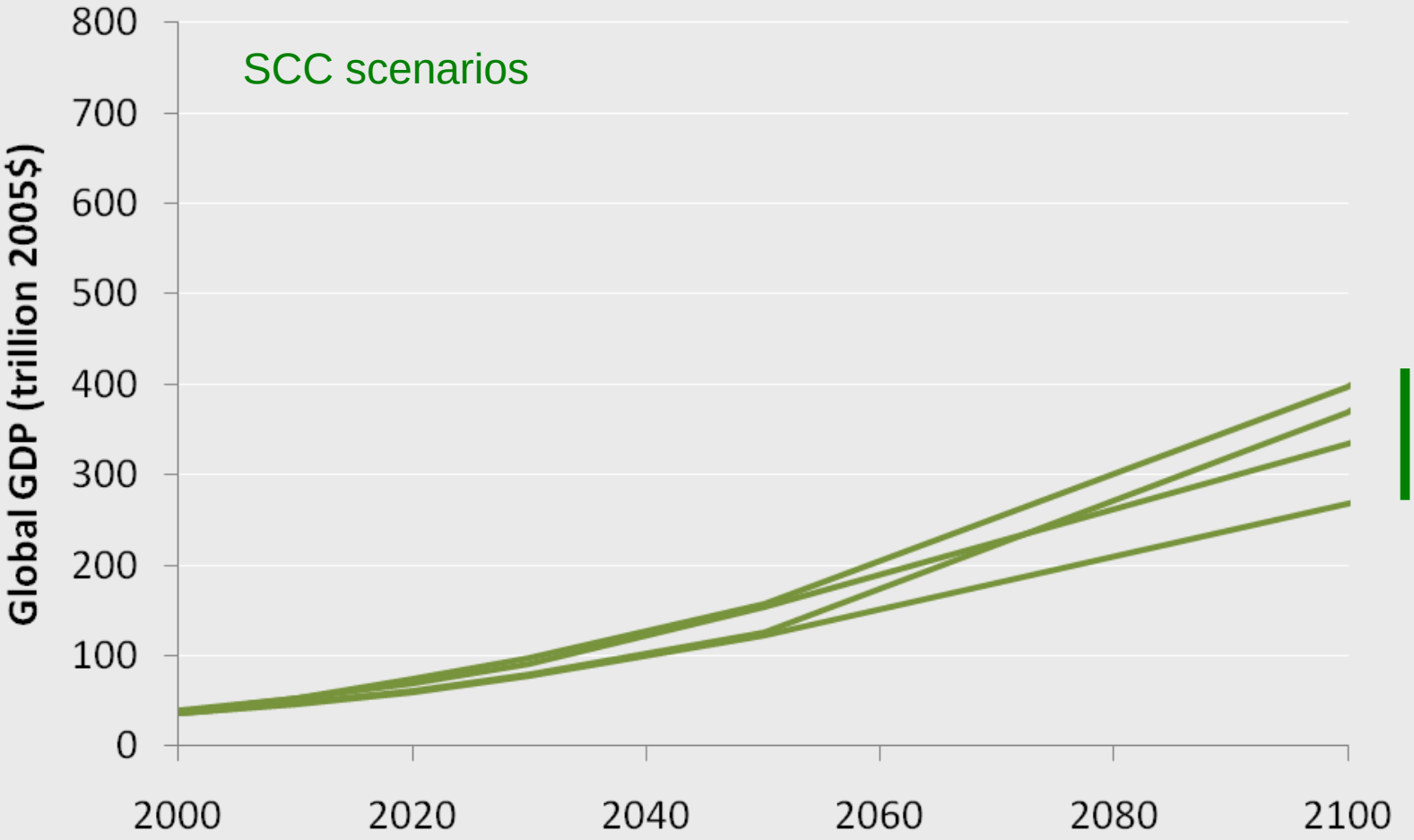


Global Population Age Structure



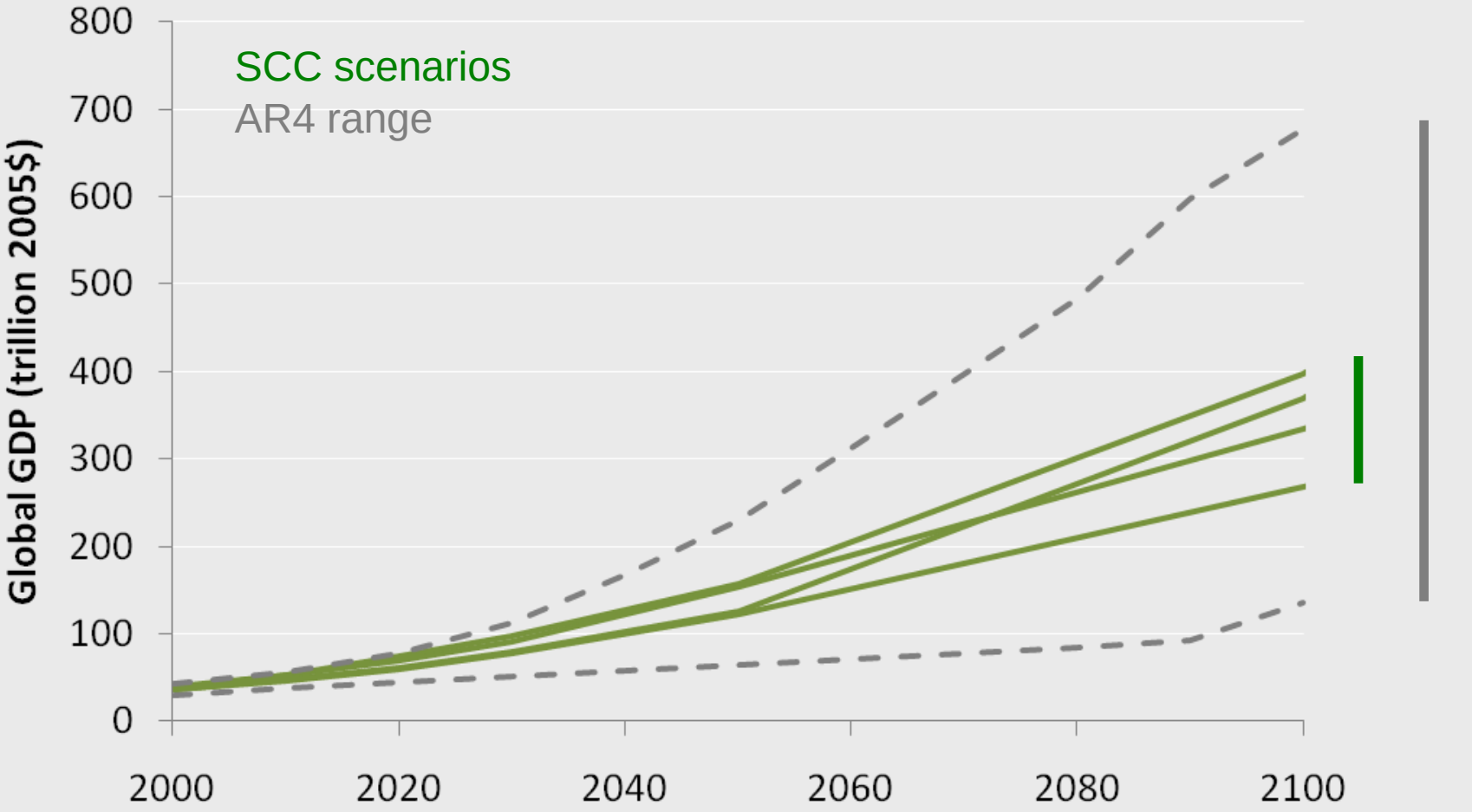
Source: Lutz & Scherbov, 2008.

Global GDP to 2100



Global GDP to 2100

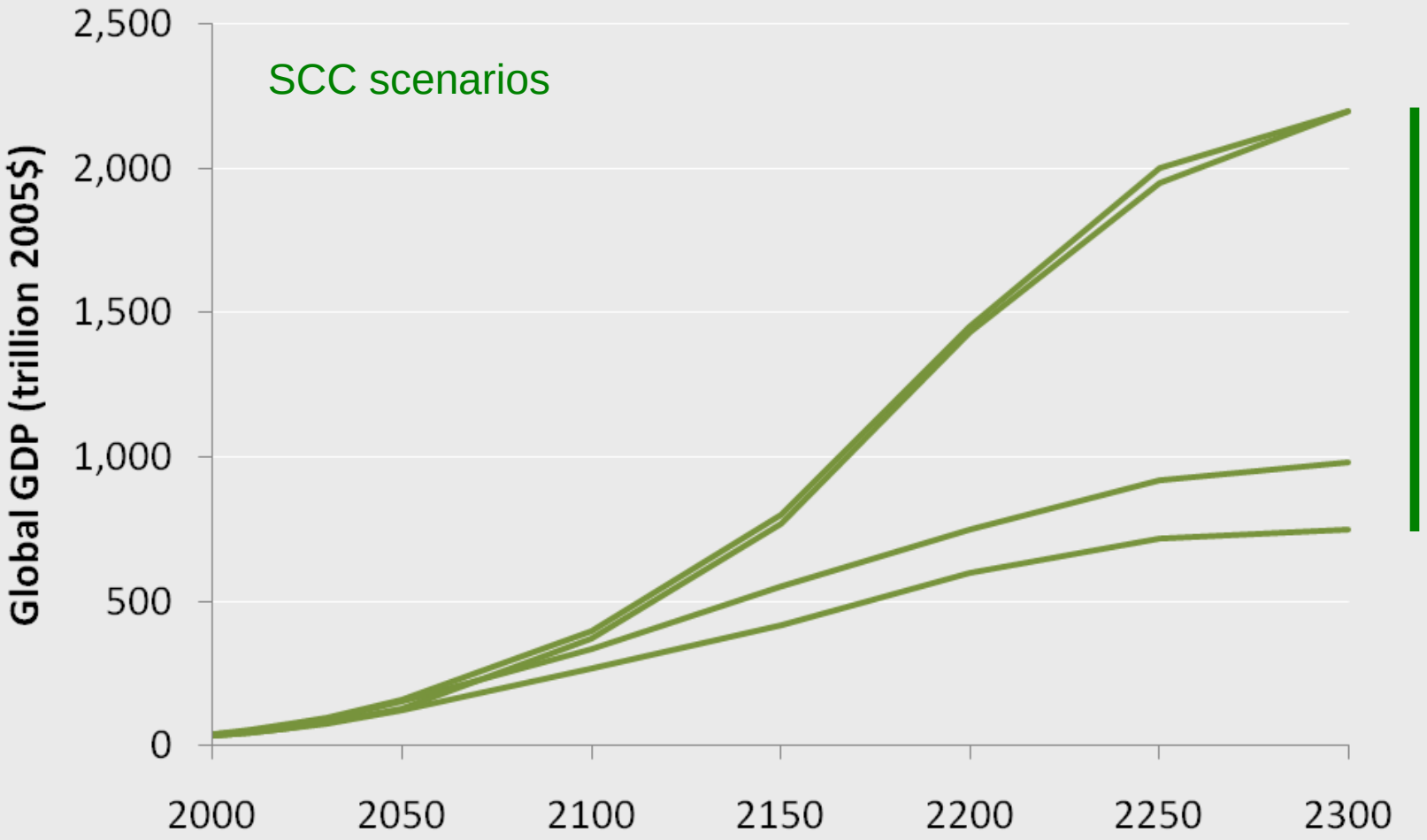
H/L = 1.5 vs. 5.0



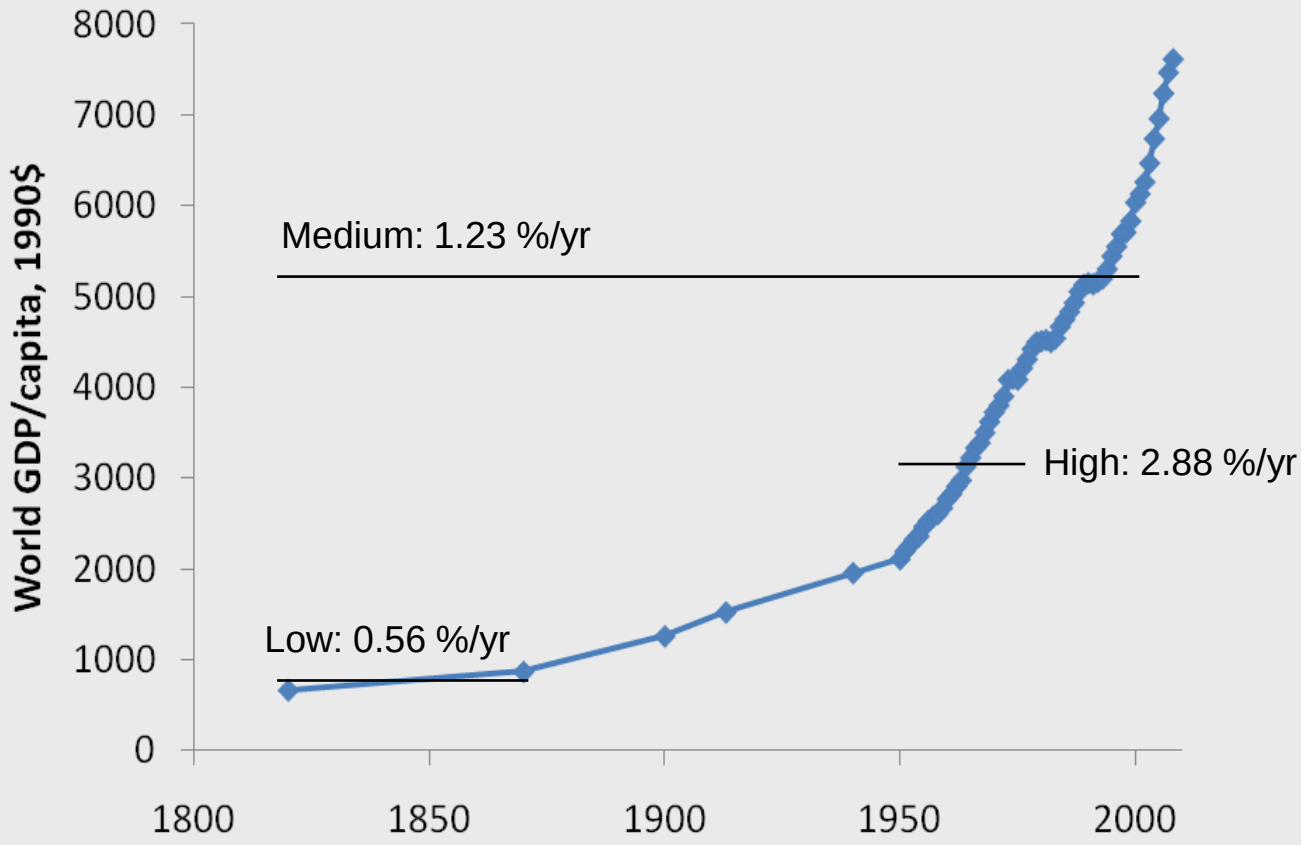
SCC extrapolation to 2300

- Growth rates of per capita GDP at end of 21st century decline linearly to zero by 2300
- Based on idea that “increasing scarcity of natural resources and the degradation of environmental sinks available for assimilating pollution from economic production activities may eventually overtake the rate of technological progress”

Global GDP to 2300

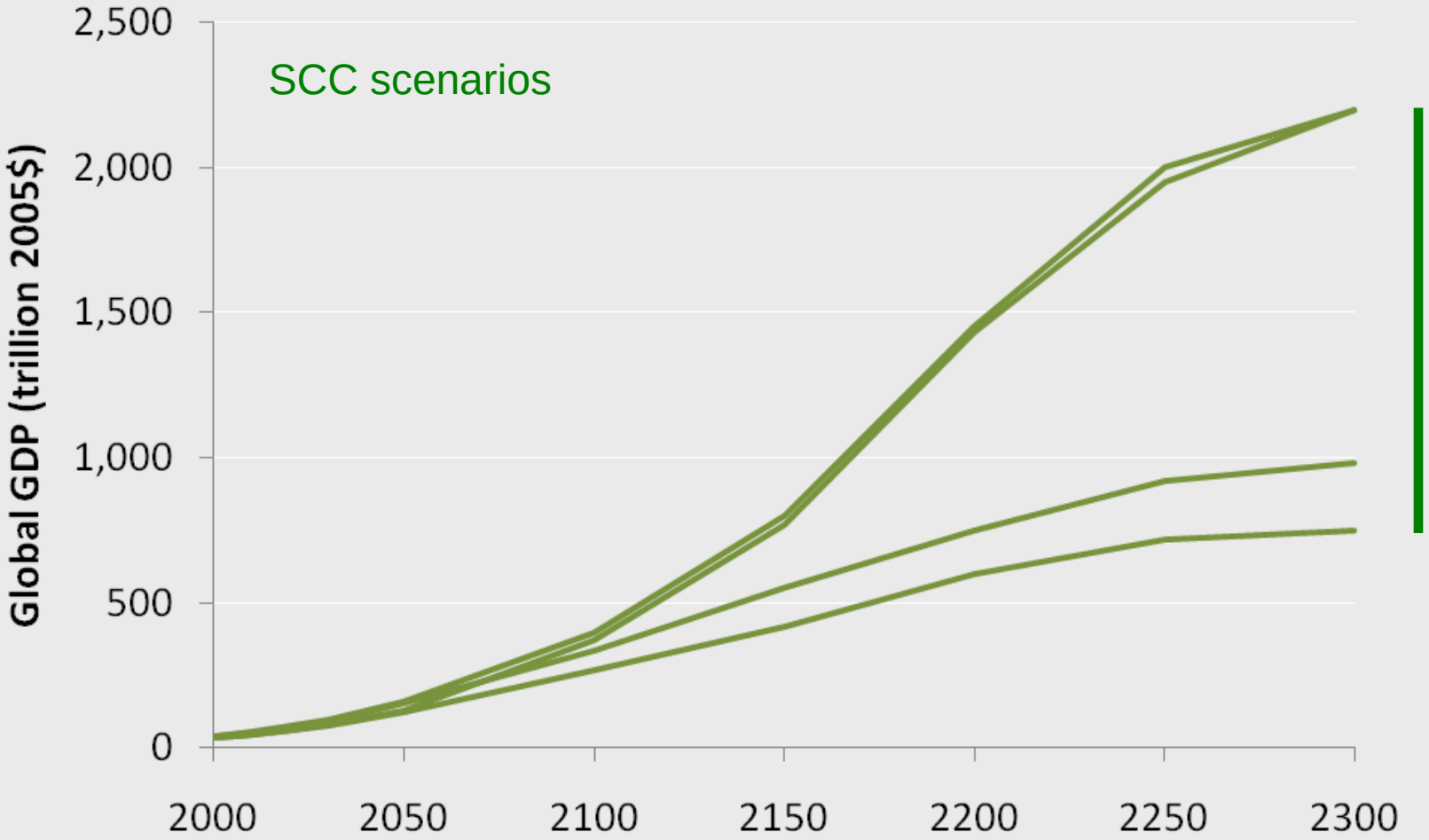


GDP Projections Based on Historical Experience



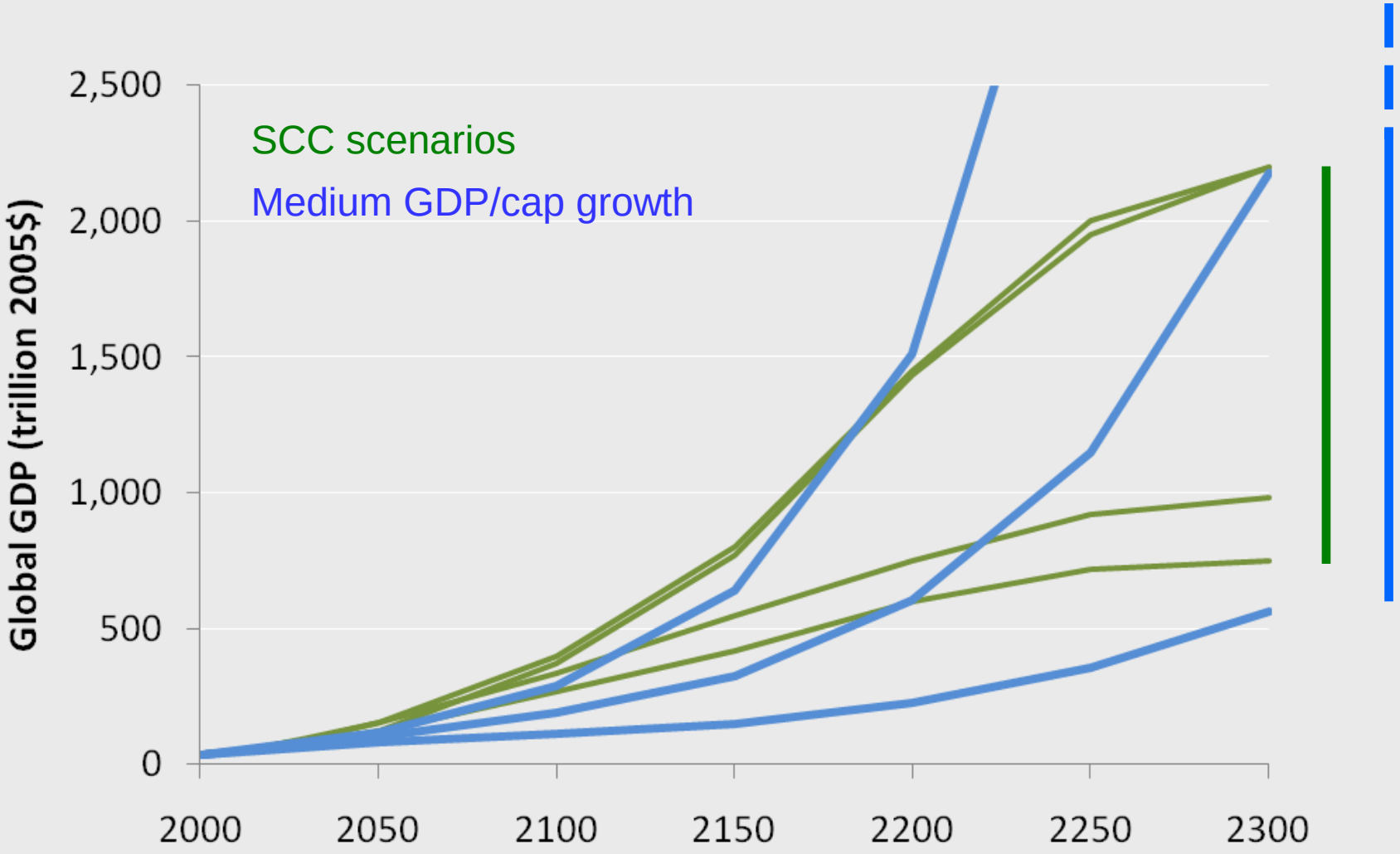
Source: Date from Maddison, 2010. After Tonneson, 2008.

Global GDP to 2300

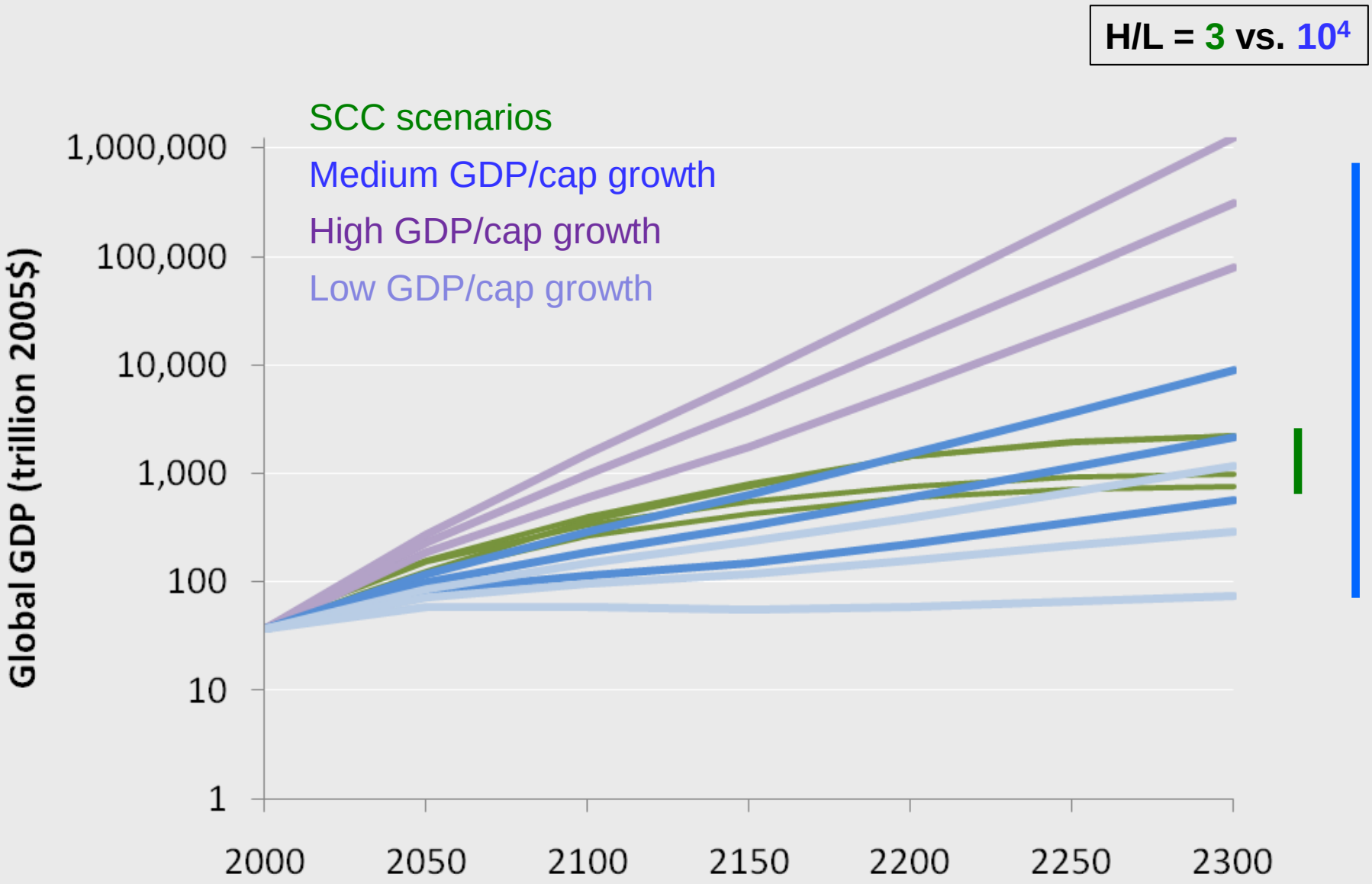


Global GDP to 2300

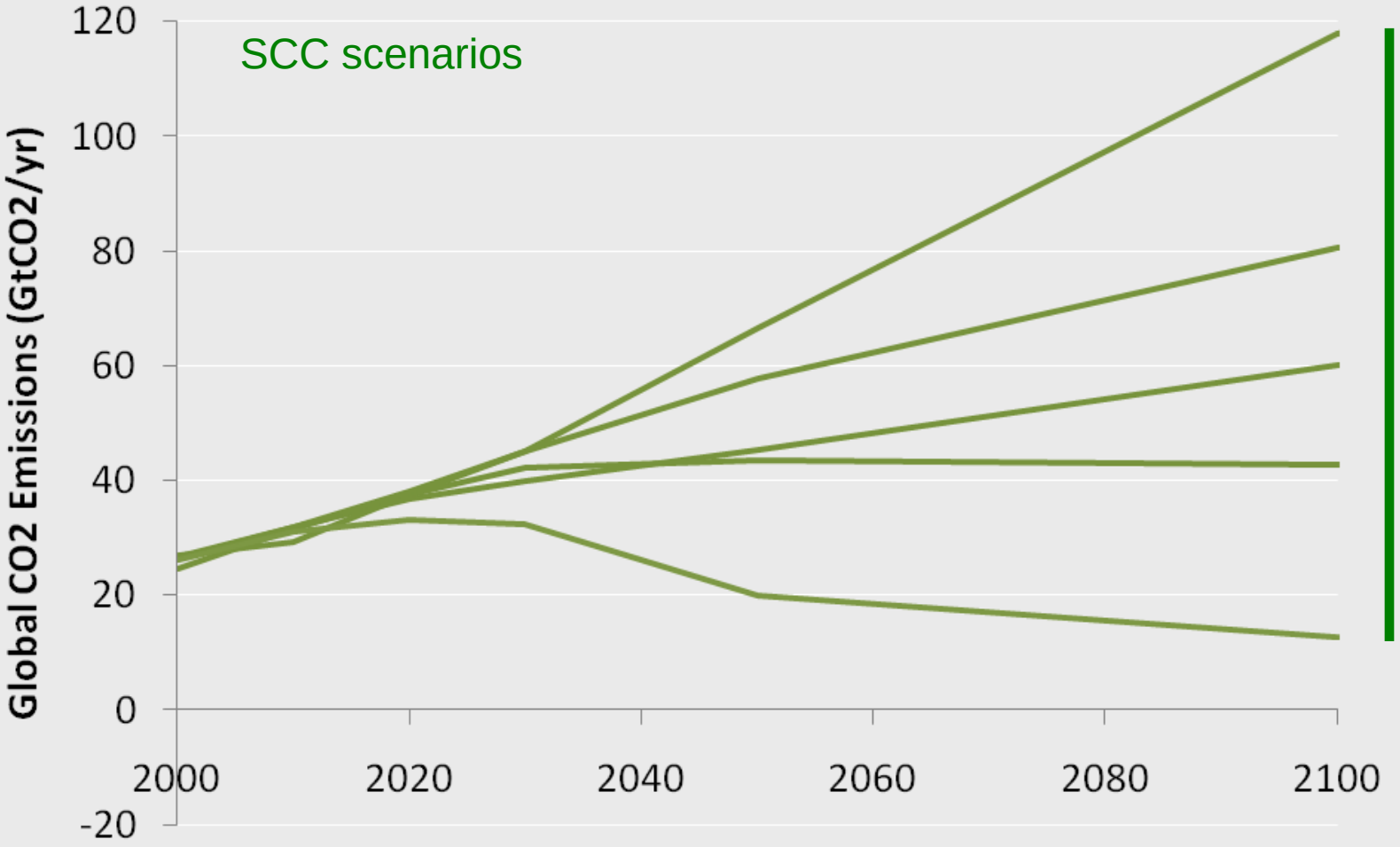
H/L = 3 vs. 16



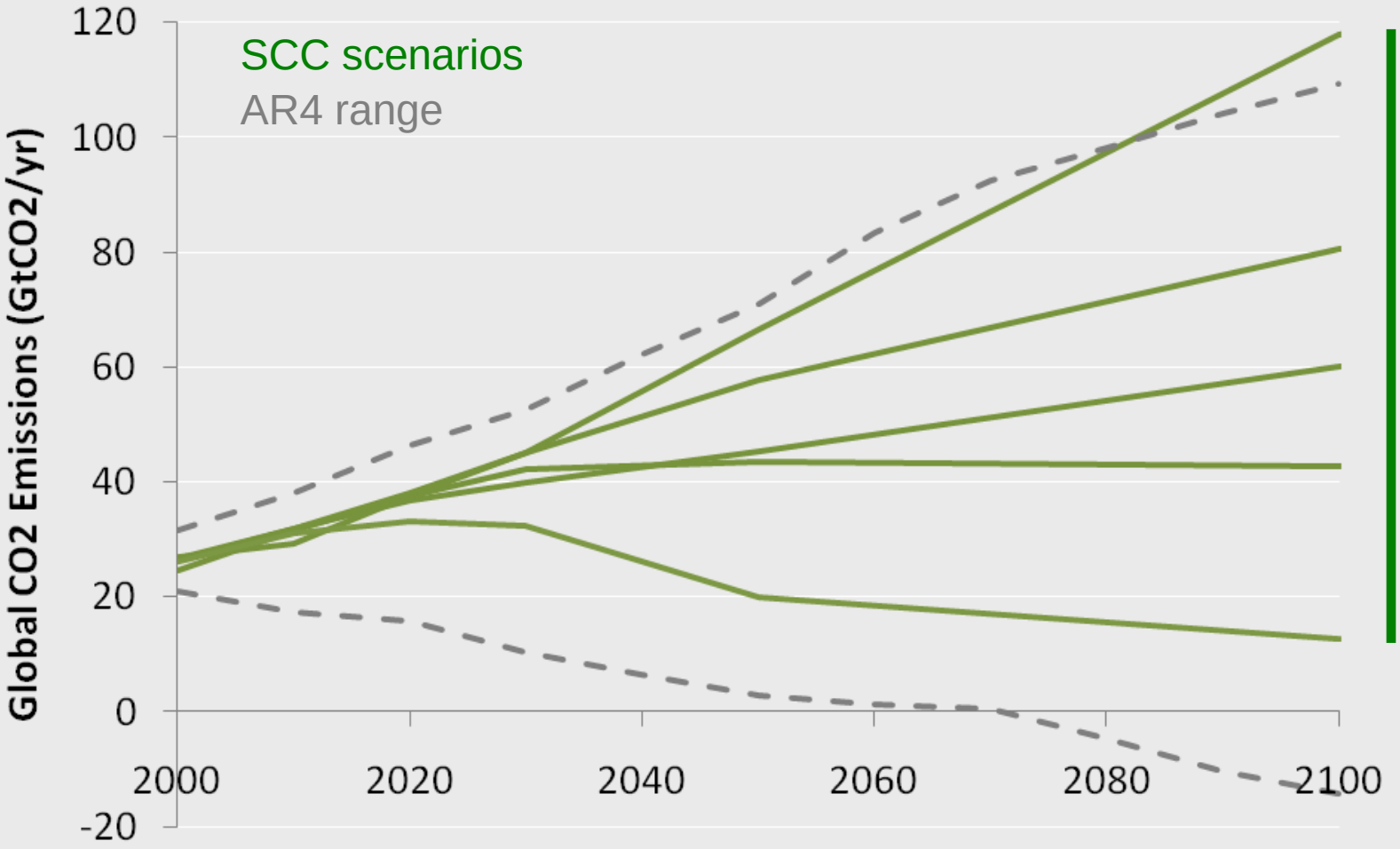
Global GDP to 2300



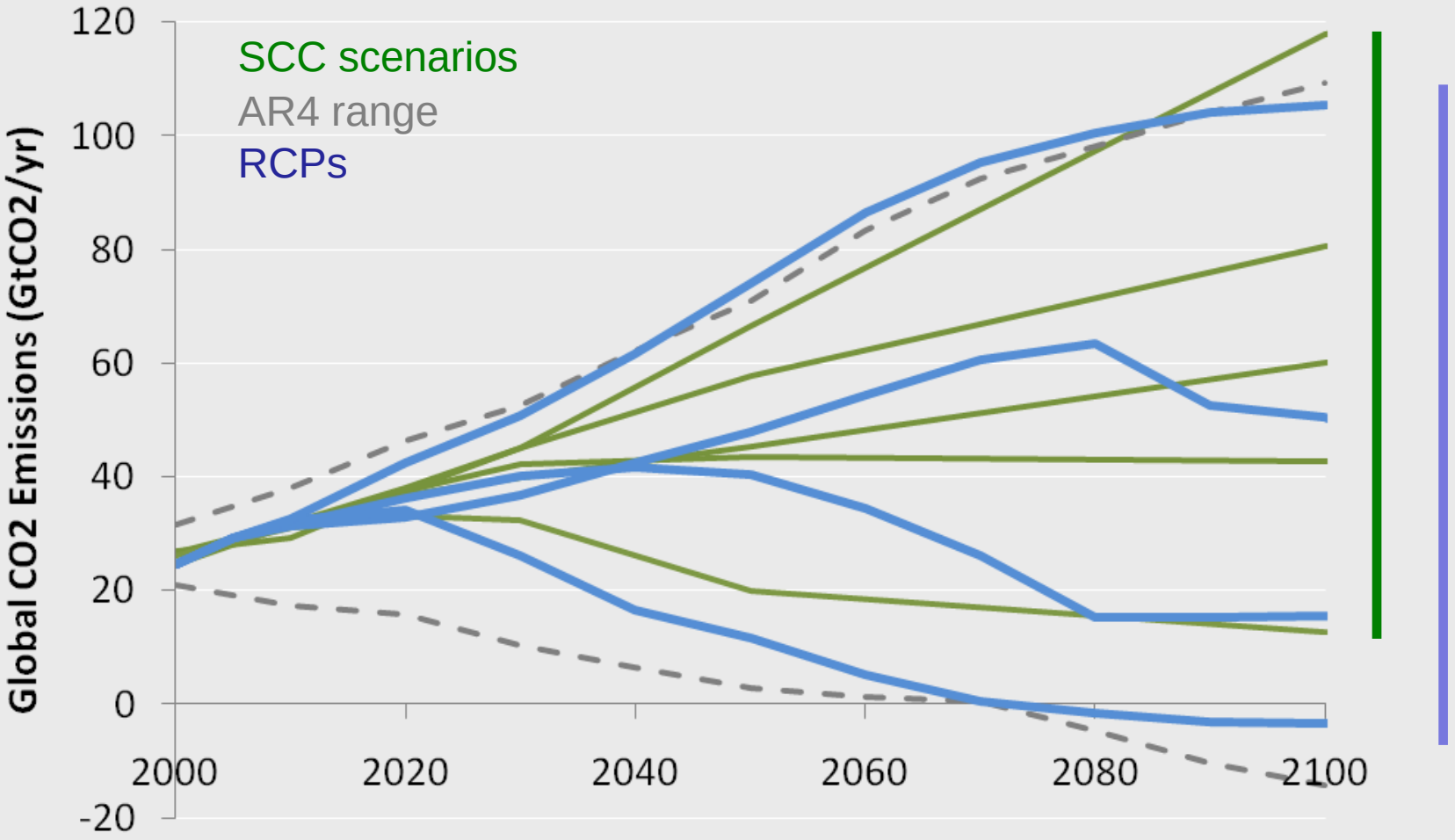
Global CO2 Emissions to 2100



Global CO2 Emissions to 2100



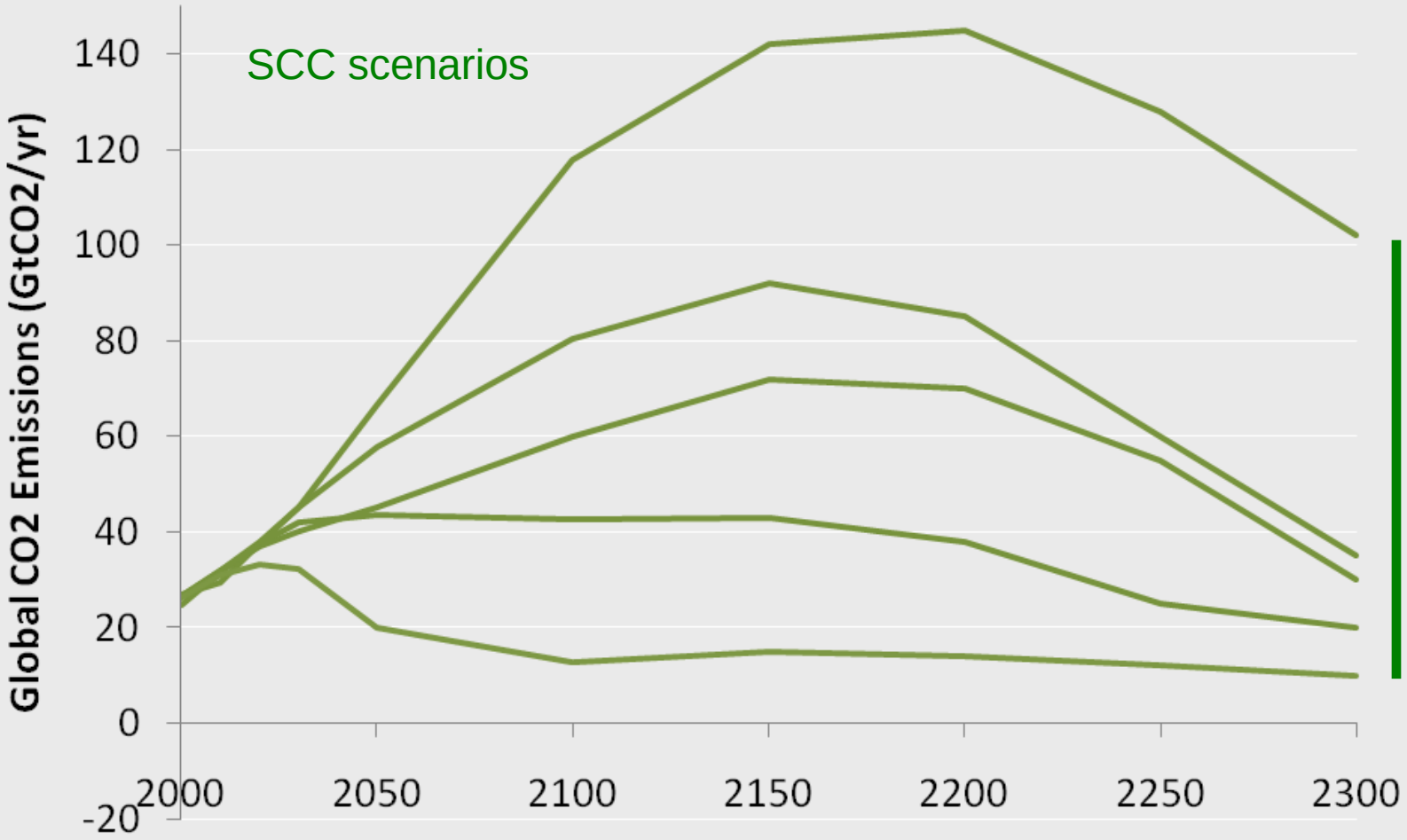
Global CO2 Emissions to 2100



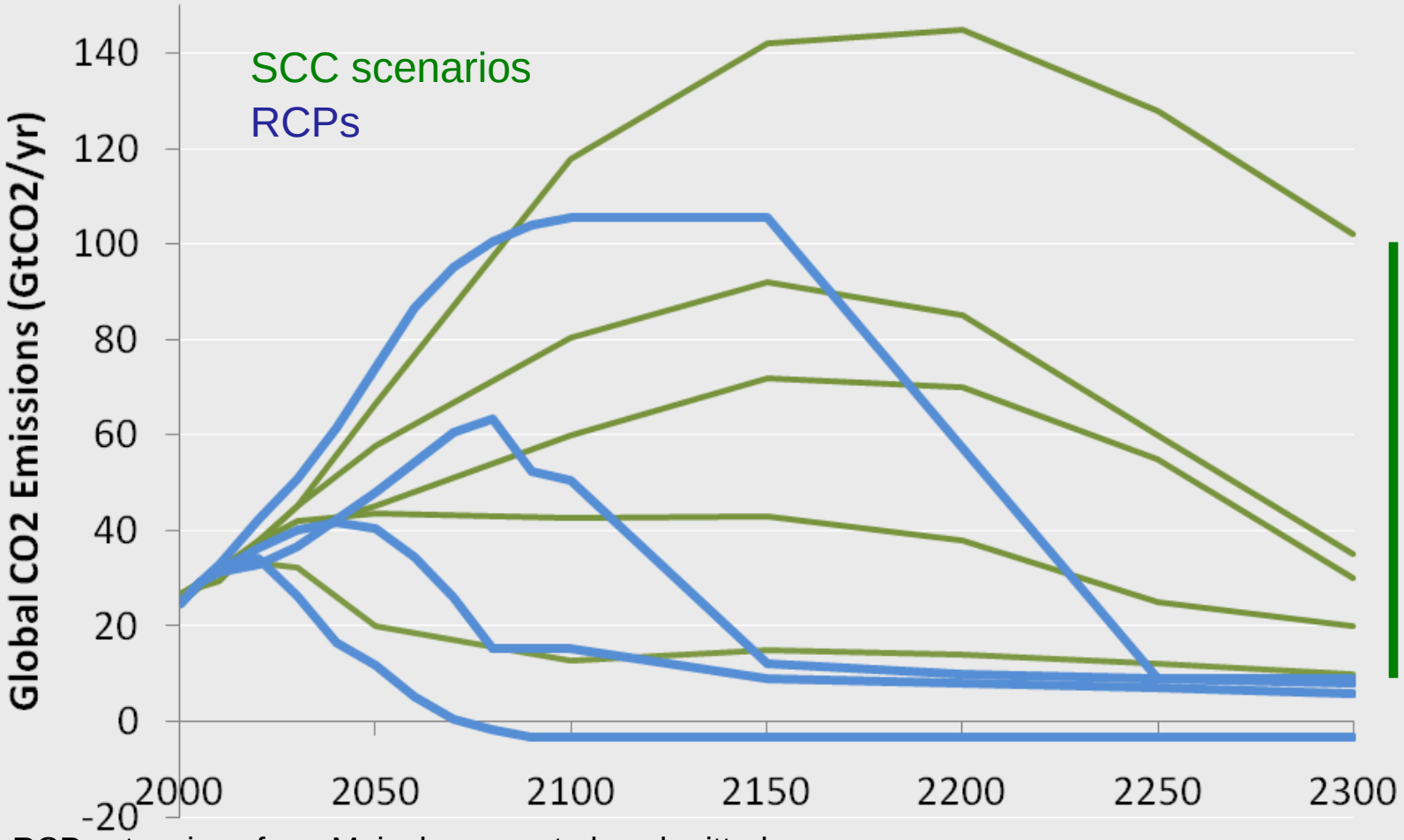
SCC extrapolation to 2300

- Growth rates (decline rates) of carbon intensity (CO2/GDP) from end of 21st century maintained through 2300
- "assumes that technological improvements and innovations in the areas of energy efficiency and other carbon reducing technologies … will continue to proceed at roughly the same pace that is projected to occur towards the end of the forecast period"

Global Fossil CO2 Emissions to 2300

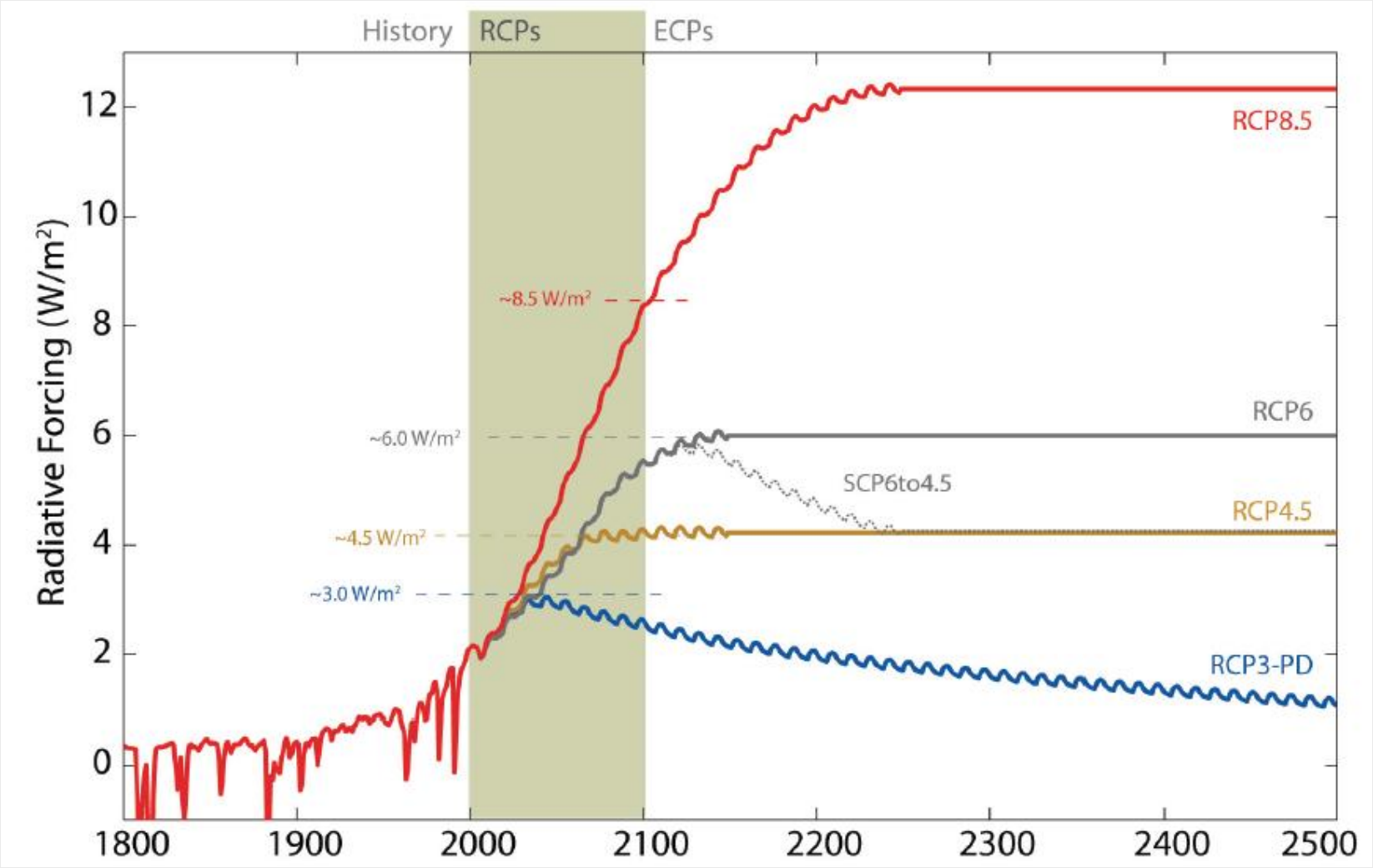


Global Fossil CO2 Emissions to 2300



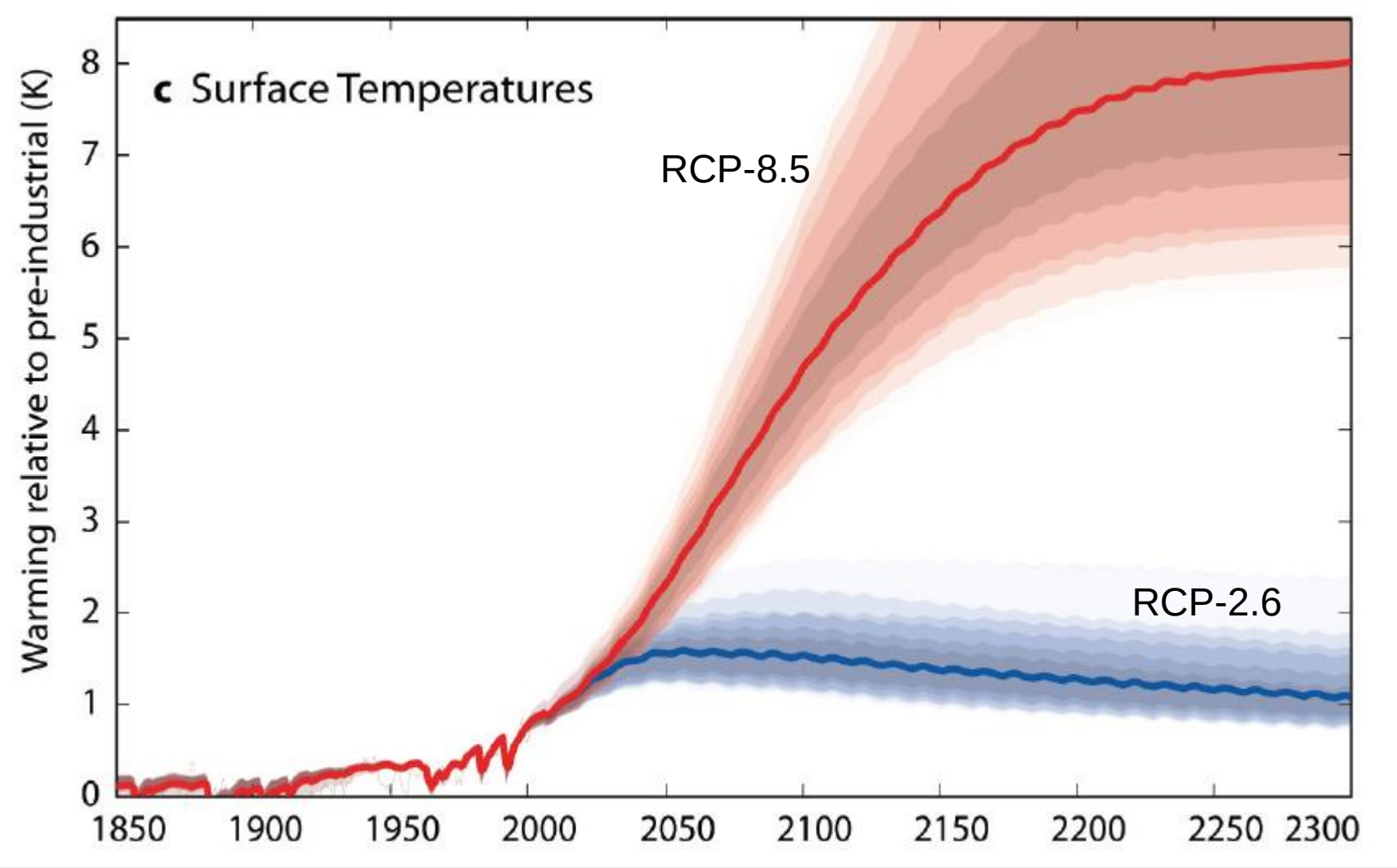
Source: RCP extensions from Meinshausen et al., submitted.

RCP radiative forcing



Source: Meinshausen et al., submitted.

RCP Temperature Projections



Source: Meinshausen et al., submitted.

Summary: Uncertainty ranges

- Overly narrow range of uncertainty in population and GDP over the entire time horizon, but especially in the long term
- Range of emissions through 2100 reasonably consistent with the range in the literature
- Range of emissions beyond 2100 higher than the range in the RCP extensions (although not clear that matters)

Issues

- **Current uncertainty ranges in literature may themselves be too conservative**
- **Structure of future economy in the long-term: what does a particular GDP/capita in 2300 mean?**
- **Regional distribution of people and production**
- **Catastrophic impacts: high emissions scenarios are lots of warming! Median of 8+ degrees by 2300**
- **Do current damage functions apply even approximately to conditions in the very long term?**
  - How relevant would a damage function created in 1700 be to measuring climate damages today?

Recommendations

- **Demonstrate key sources of uncertainty, including the contribution to SCC from different time periods**
- **Drop the use of a range of best estimates**
  - "single scenarios" are used for extensions beyond 2100, when uncertainty is greatest
- **Consider a substantially wider range of socio-economic futures, through 2100 and 2300**
- **Consider simpler approaches to damages in very long term: generic sectors and damage types**
- **Improve how uncertainty in results is characterized**
  - Use of probabilistic terms for SCC results is problematic when only sub-components are quantified (i.e., results are highly conditional)
- **Consider linking to evolving work on RCPs and socio-economic scenarios that are consistent with them**